ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

ECOSTRESS Instrument Performance

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Topics:

- Overview
- Product Generation and Traceability
- Calibration and Validation Measurement Plan
- Performance
- Hardware Set-up

Performance Overview

Instrument performance is assessed though radiometer calibration during I&T. It consists of the following system level measurements:

Measurements repeated (*validated*) during payload I&T

- Noise equivalent delta temperature (NEΔT) per spectral channel
- Absolute radiometric accuracy (linearity) per spectral channel
- Modulation transfer function (X and Y track)

Measurements exclusive to radiometer I&T and <u>do not</u> need to be repeated/validated during payload I&T

- Saturation temperature (define thermal optics contribution)
- In-band and out-of-band spectral response function (SRF) using monochromator and target projector.
- Radiance versus angle (RVS, capture NEΔT and system linearity to input stimulus at the edges of the field of view)
- Geometrical field of view distortion map
- NIST traceability of blackbodies using transfer radiometer (in air)

Measurements exclusive to payload I&T

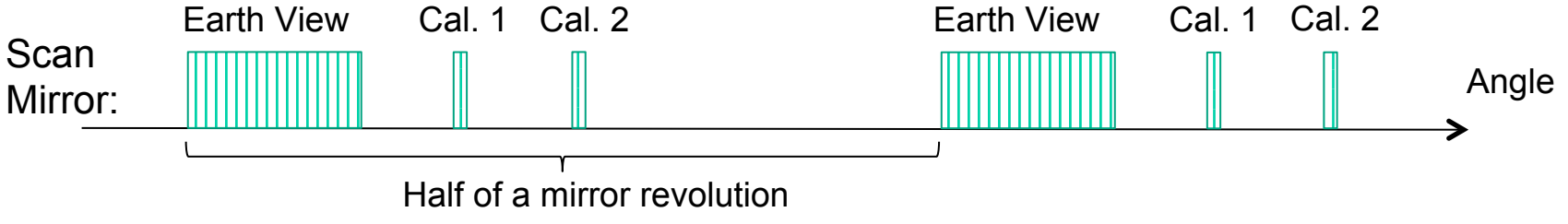
- Out-of-field rejection to confirm stray light rejection (requires all hardware be present to raise the payload box temperature to the expected temperature)

Product Overview

1. Focal plane pixel column selection and optimization based on a predefined set of criteria. The optimum set will be delivered to the instrument team and will need to be implemented as a hardware register command.
2. Surface temperature vs. imbedded PRT calibration coefficients for Hot blackbody using SI traceable transfer radiometer in SAF.
3. Surface temperature vs. imbedded PRT calibration coefficients for Cold blackbody using SI traceable transfer radiometer in SAF.
4. Spectral/system response functions – using monochromator and collimator in SAF.
5. Geometrical distortion verification ("Camera Model") – single field of view using the collimator in SAF and TVAC.
6. Focal length verification– single field of view using the collimator in SAF and TVAC.
7. Noise model with NEΔT – using large aperture portable blackbody source as well as two blackbodies in TVAC (with SI surface traceability).
8. Linearity model with defined saturation temperature– using large aperture blackbody source (with SI surface traceability) in SAF and TVAC.

Calibration Overview

- Two high emissivity calibration targets are integrated in the radiometer scanning operation.
- Every Earth view measurement is bounded by a two-point calibration to remove detector gain and instrument thermal background variations every half-scan rotation. This allows the captured scene to be flat fielded.

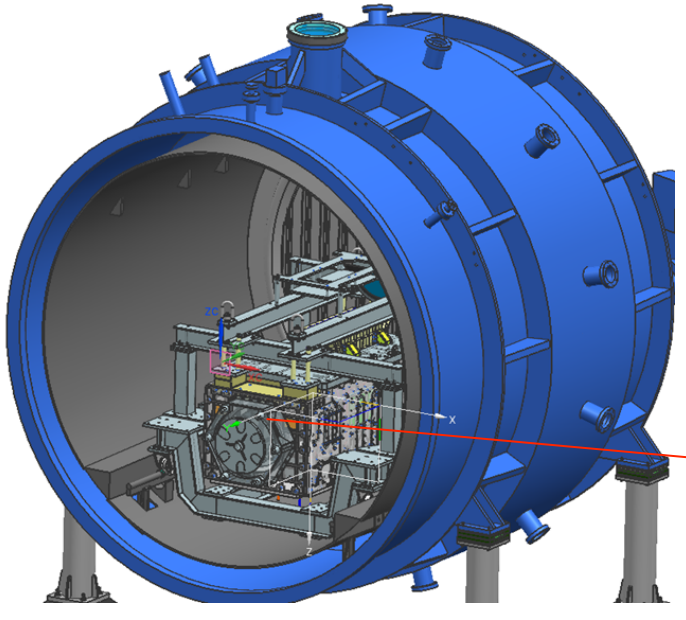


- The on-board calibration targets are maintained at approximately 295K and 320K.
- Exposures will be captured of each blackbody along with measurements from the imbedded PRTs. The PRTs are traceable to pre-flight measurements.
- The blackbody surface emission-to-PRT traceability to NIST is performed during radiometer I&T. The certification is transferred to the orbiting radiometer blackbodies using a NIST traceable transfer radiometer.

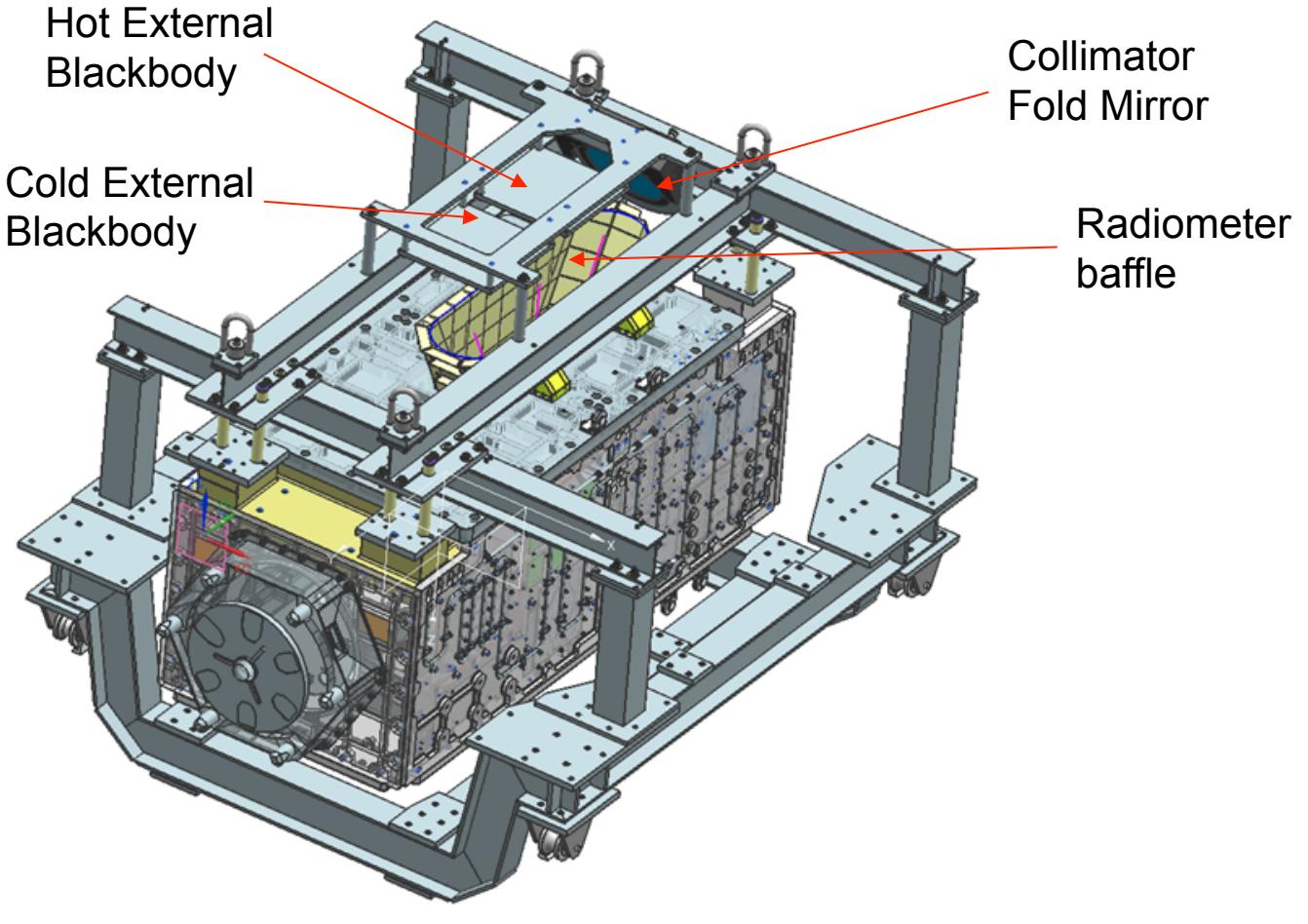
Calibration Traceability

- JPL has multiple NIST traceable blackbodies with a stability at 25°C of +/- 0.0007°C and a thermistor standard probe with an accuracy of 0.0015°C over 0-60°C and a stability/year of 0.005°C
- These data are readout using a system with an accuracy of 0.0025°C at 25°C and resolution of 0.0001°C. Calibration is performed in a ramp and soak mode where the blackbody temperature is increased by a set interval and allowed to soak for several minutes and then the temperature is measured.
- Portable radiometers will be used to transfer the traceable thermistor probes to the skin temperature of the onboard blackbodies, hence the imbedded platinum resistance temperature detectors (pt-RTDs) (PRTs).
- Stability of imbedded pt-RTDs ~50mK / 5years.

Hardware Set-up for Validation



Payload in TVAC chamber



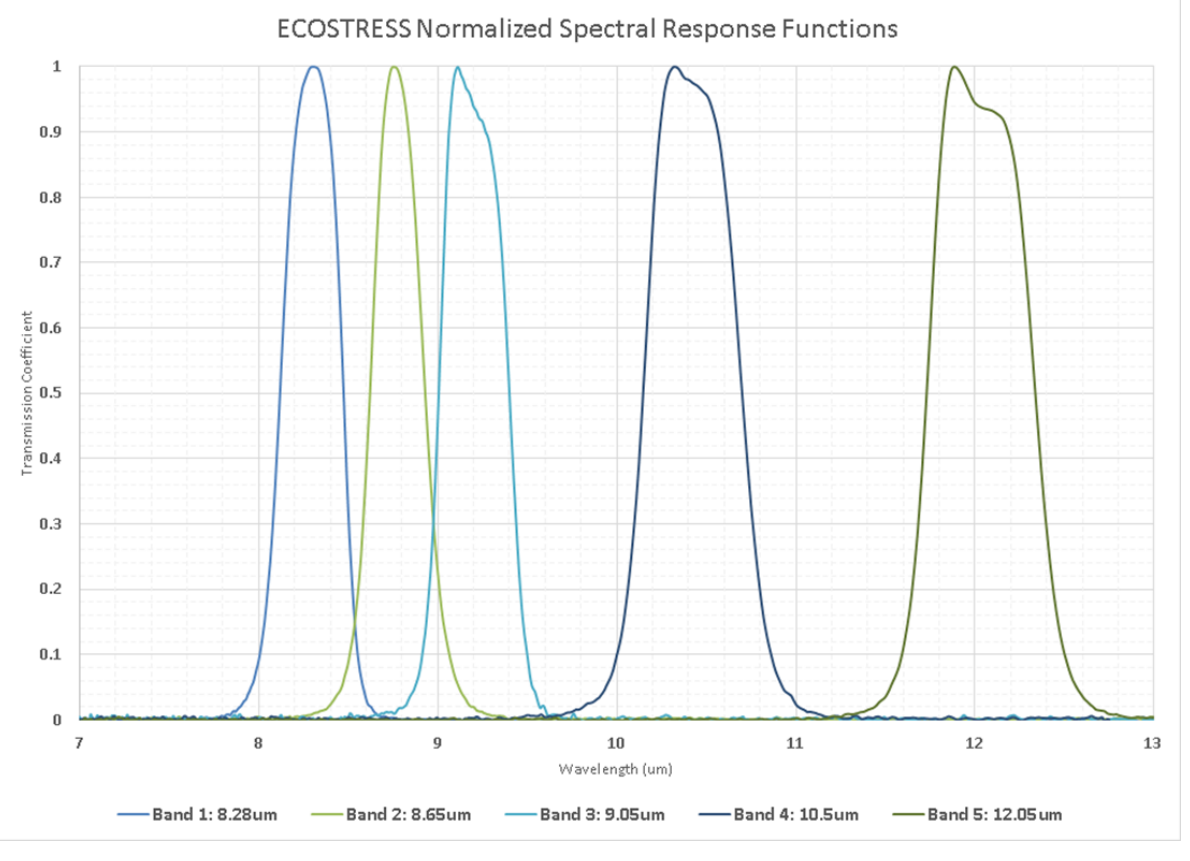
Payload in TVAC chamber with calibration/ validation hardware

Measured Parameters

Dark current noise is approximately 200e-

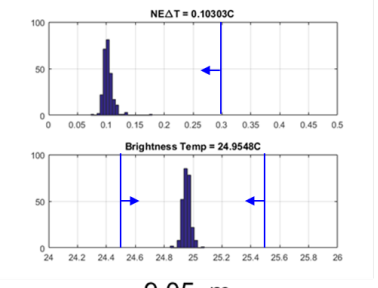
Read noise is approximately ~1000e-

Band	QE	Sat temp (C)
8.28	0.665	113.85
8.63	0.665	85.85
9.05	0.748	90.85
10.5	0.629	94.85
12	0.334	161.85

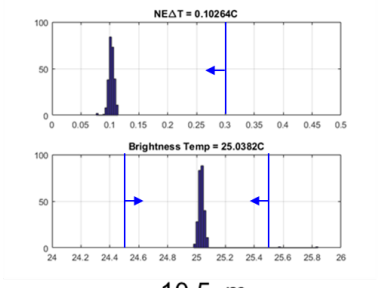


Radiometric Performance

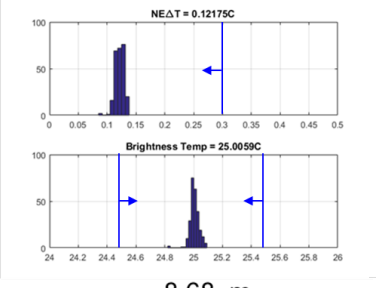
Radiometric Performance at Required Scene Temp = 25C



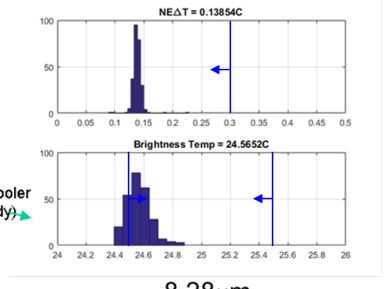
9.05µm



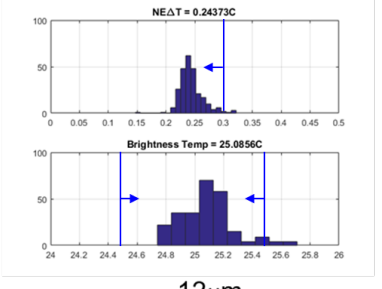
10.5µm



8.68µm

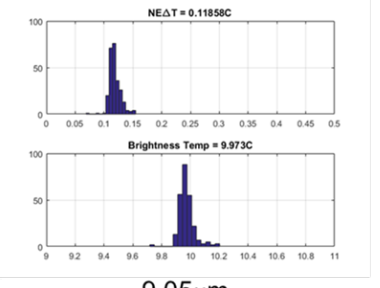


8.28µm

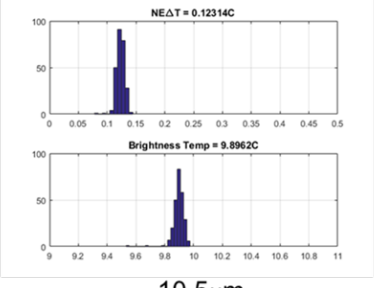


12µm

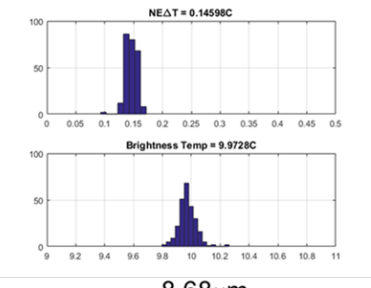
Additional Radiometric Performance at Scene Temp = 10C



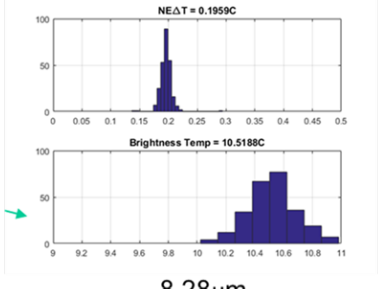
9.05µm



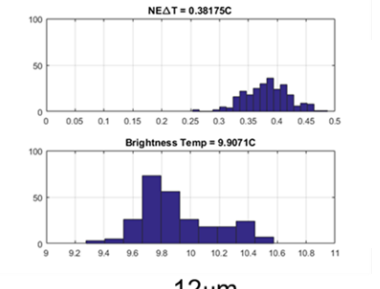
10.5µm



8.68µm



8.28µm

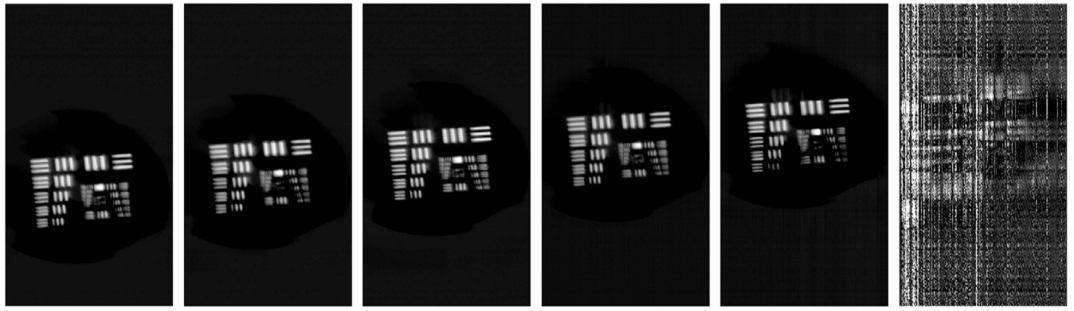


12µm

Spatial Performance

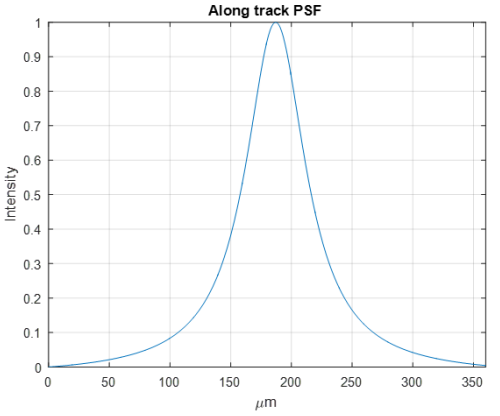
Spatial Performance

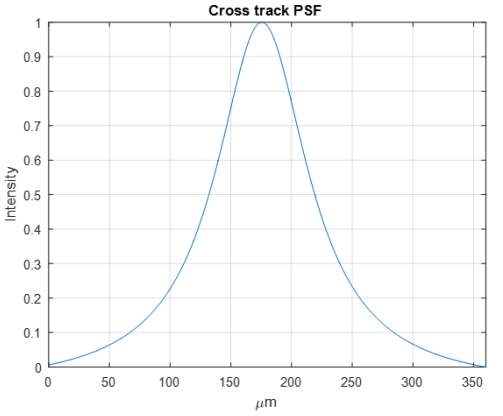
9.05µm 10.5µm 8.68µm 8.28µm 12µm SWIR

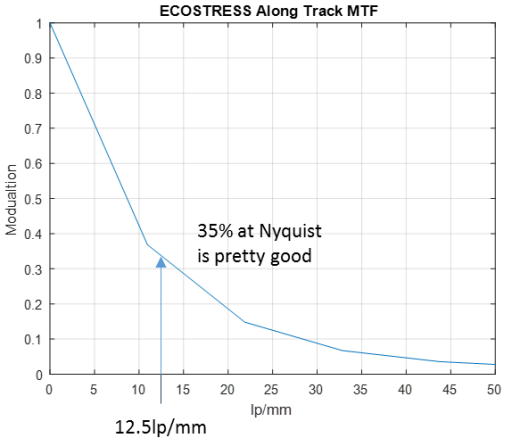


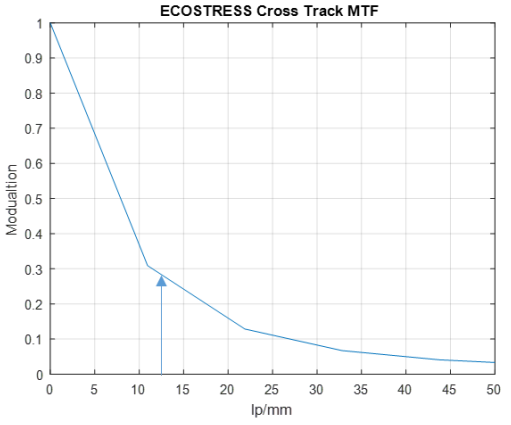
No SWIR light used in this test (will start tracking it going forward)

The Air Force bar chart has a range of spatial frequencies beyond the resolution of the ECOSTRESS Radiometer. Half of the target will have good focus while half (smaller features) will not.





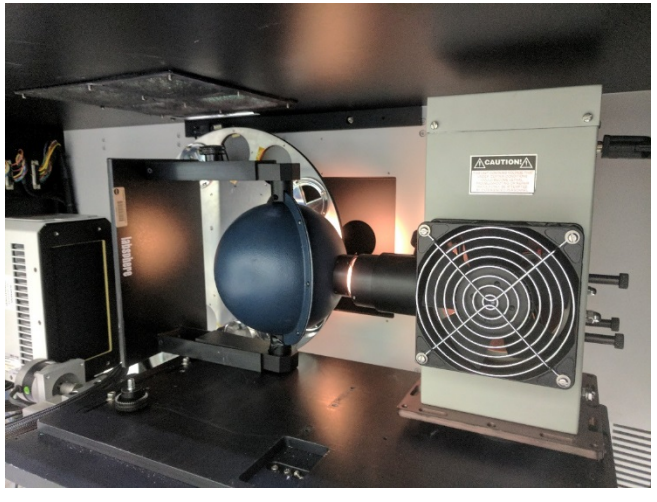




64% at 6.25lp/mm
52% at 8.33lp/mm

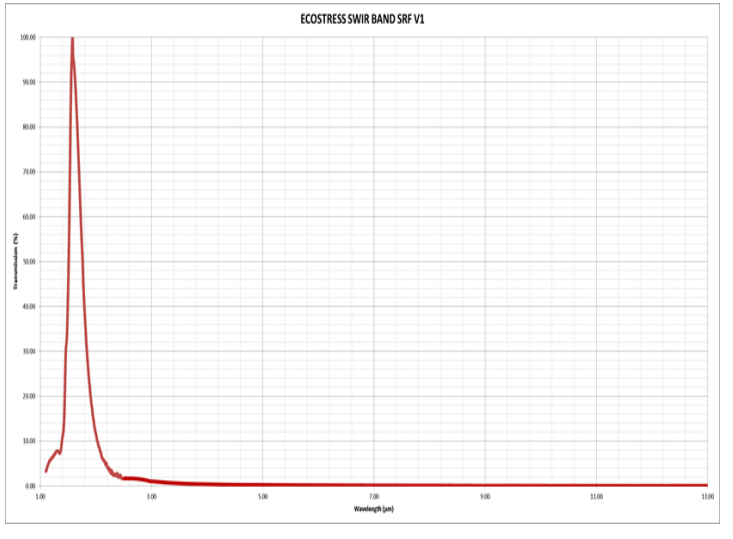
60% at 6.25lp/mm
47.5% at 8.33lp/mm

SWIR Channel

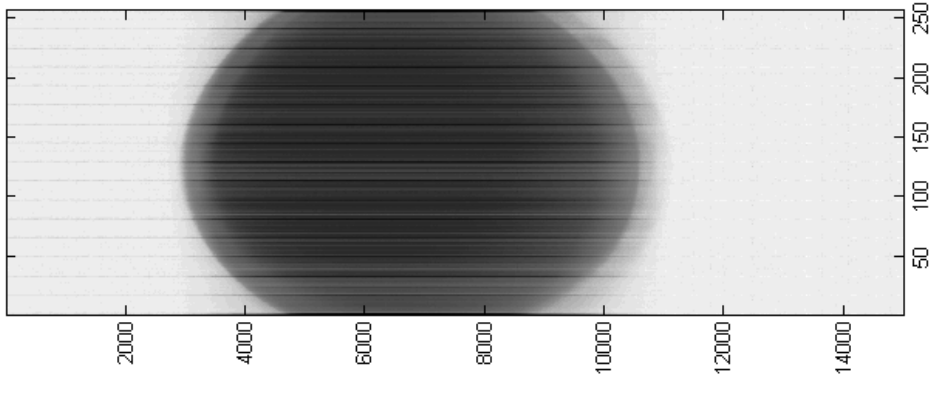


Integrating sphere at collimator input

- 200W QTH source
- Target projector
- Inverted contrast

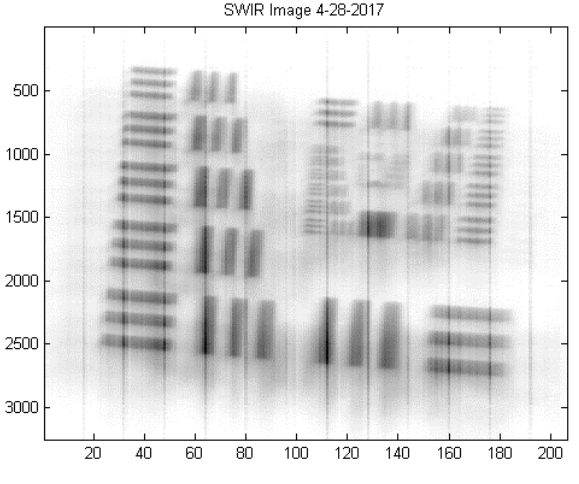


Filter totally blocks thermal signal while allowing SWIR to pass.

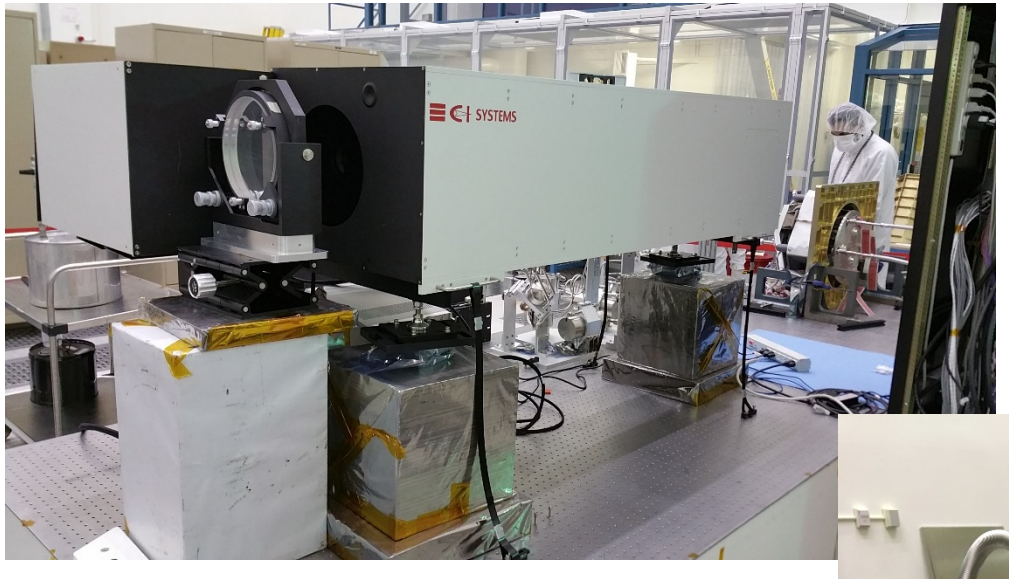


Unprocessed SWIR Band Flat field Scanning

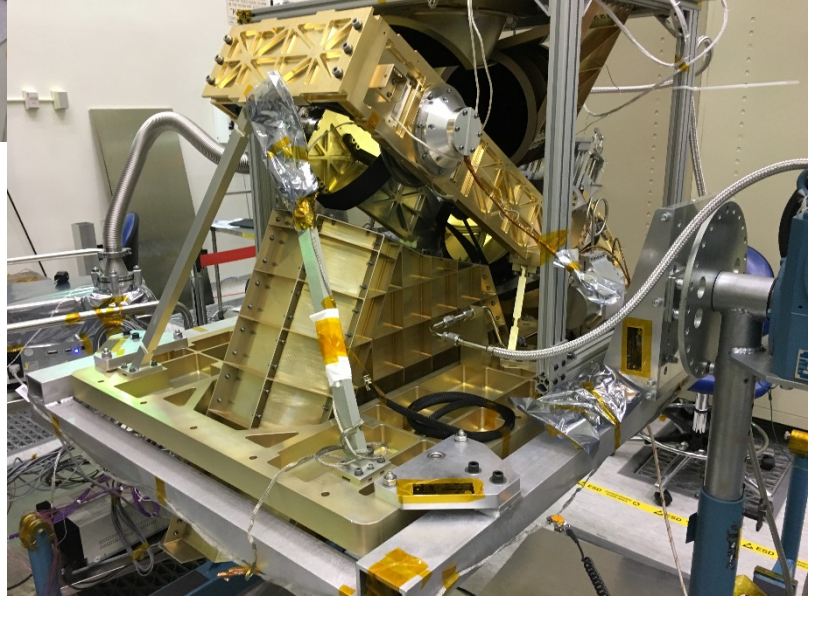
Unprocessed SWIR Band Illuminated Bar Chart



Path forward



Verification of collimator in SAF



NADIR Baffle: Radiance Vs. Angle Measurement

Measuring scan head magnification